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FACTS AND THEORY.

THE basis of all true knowledge is facts, and the foundation of all exact theory is the correct conception of these facts. A physical fact of itself is irrefragable; but owing to imperfect observation, to want of preparation in the mind, to unskilful manipulation, and to other causes, inferences from facts are often mistaken for facts themselves. Herbert Spencer has shown, in his "Sociology," how various biases of the mind tend to distort our judgment on social, political, and scientific facts, and he has himself given a notable instance in his own person, in this book, how a fine mind can be so prejudiced as to utterly ignore the results of experience. Hence it becomes essential to draw a great distinction between facts and inferences from facts, and to examine carefully theories to see whether they are based on the latter or on the former. There is a great tendency in the human mind to theorise. The idea to sift to the core, to reach at the very bottom of things, is intuitive. The observation of any effect, the learning of any fact, is instantly followed by the desire to know the cause; and if an explanation be not forthcoming, the mind at once seeks to arrive at its own conclusion. If this innate operation of the mind is allowed to act on the true conception of facts, we have what has been happily called the scientific use of the imagination; if, on the contrary, it acts on erroneous inferences from facts, we have the scientific abuse of the imagination. The latter condition is more frequent than the former. The result in the first case is true theory; in the latter case mere hypothesis, and often wild and injurious conjecture.

The various phases in the history of the theory of any science are very instructive. Facts remain fixed, but how the explanation of those facts have varied! The moon has continued to course around the earth, the earth around the sun, the planets retain their orbits as in the days of Hipparchus and Ptolemy; but how different the explanation of their movements as given by those ancient astronomers—and subsequently at different periods—by Copernicus, Kepler, Descartes, and Newton. The light from the sun, the twinkling of the stars, the colours of the rainbow, and the various hues of the floor of Nature, are the same now as when they gladdened the heart of Noah; but Euclid and the Platonists maintained that vision is exercised by rays proceeding from the eye, not to it; Newton conceived it to be due to excessively light particles of matter emitted from the luminous body impinging upon the retina of the eye; and Young has showed it to be due to the vibrations of an infinitely subtle and elastic medium, filling all space and permeating matter. Summers and winters warm and cool us now as they did of yore, food is cooked, water is boiled, metals expand, and fire levels our habitations to the ground as in the days when the burning bush attracted Moses. Yet while the incautious ancient thought that a boiling kettle into which he dipped his finger was a beast that bit him, even the modern has thought that heat was a form of matter, and the notion that it is a mode of motion is only now creeping into general belief.

Chemistry, within a comparatively recent period, has run through a complete cycle of changes. For twenty centuries the scientific world was satisfied with a belief in the existence of four elements,—earth, air, fire, and water. It then invented phlogiston, a kind of matter which being abstracted from a body actually added to its weight,—a veritable levitating medium,—to account for the composition and decomposition of substances. Lavoisier discovered oxygen, and introduced dynamical principles into the science. Dalton introduced the conception of atoms, and now we have the molecular theory established on as firm a basis as that of gravity or light.

The nature of Electricity is still wrapt in mystery, and the theory of its existence and action is mere vague speculation. Thales imagined excited amber to be animated with a kind of life; Boyle imagined an electrified body to throw out a glutinous or unctuous effluvium; Newton conceived that, in such circumstances, an elastic fluid was emitted; Du Fay, Franklin, and Symmer suggested various phases of the fluid doctrine, and now modern physicists are driving the theory through the same stages which caused light and heat to emerge from the material to that of the molecular or vibratory form. Thus we see that as our knowledge of facts increases, so does our perception of their true meaning improve, and so do our theories emerge from vague hypothesis to well-established doctrine. Theory based on inference or imperfect knowledge is a phantom of the scientific dreamer, but based on the true knowledge of facts it is the solid instrument of the philosophic explorer. Hence it becomes so essential that we should have a thorough knowledge of the facts before we attempt to theorise on those facts, and so important that we should resist the innate tendency of the mind to make use of the imagination in an unscientific groove.

THE VOLTAIC BATTERY.

A Course of Six Lectures,

By Dr. JOHN HALL GLADSTONE, F.R.S.,
Fullerian Professor of Chemistry, Royal Institution.

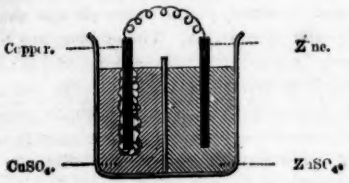
Delivered at the Royal Institution of Great Britain.—Christmas, 1874-5.

(Continued from page 40.)

Lecture III.—Electrical Decomposition.

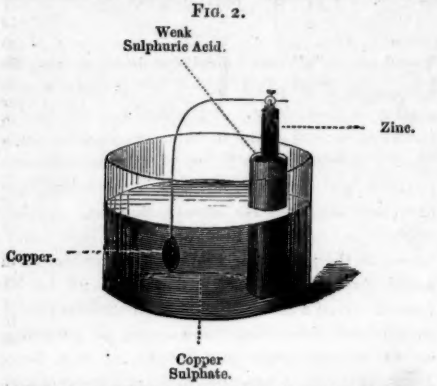
In my last lecture I spoke entirely of the replacement of metals, and I showed you, by such illustrations as could be exhibited on the screen, that there was a difference between metals with regard to their disposition to remain in combination, that one metal was capable of turning out another, and that we could arrange the metals in a long series according to their power in this respect. I showed that, when one metal was put into a solution, it turned out another metal, first by what was called chemical action or chemical affinity; but that what begins as a chemical act soon passes on to be a voltaic effect, and that, in fact, the new metal is deposited on the old metal at a distance. Now you saw this in a variety of ways; for instance, those branching crystals that we exhibited on the screen. I am very happy now to be able to hand you engravings of some of those beautiful crystals. I put at the end of the notes of the last lecture a statement that this replacement of metals was taken advantage of in certain arts. For instance, in the tinning of pins, and in the simpler sort of electrotypes. I had not time to speak of these two things, and the pins may very well be passed over; but I should like to say just a word about simple electrotyping, because it is in fact just the enlargement of what I showed you with the double cell. You

Fig. 1.



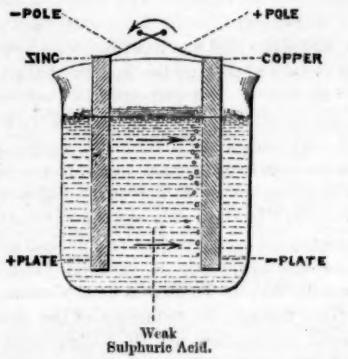
recollect how, in the divided cell, by putting zinc and copper plates into salts of those respective metals, we got the zinc continuously dissolved, and fresh copper deposited on the copper plate. Now this property can be taken advantage of in another way. Any of you can do it. You can take a porous cell, which is easily obtained, so as to separate one liquid from the other, and then you can take a piece of zinc, and fasten to it by a wire any copper medal or similar object; place the object to be copied in the outer vessel in a solution of copper, and the zinc inside the porous cell in a solution of sulphate of zinc, or sulphuric acid, and you can produce the effect you want. I will just set it working now, and at the end of the lecture we will take it out and see what it looks like. This is an arrangement which is employed actually for commercial purposes. We had a similar electrotype bath at work during the last lecture, and we produced this medal which I now hold up. [This was further illustrated by diagrams.] Now, in each of these cases you will find just the same action as in the formation of the silver tree, and in all similar decompositions. There is a change in the liquid. The liquid, as I said before, in all these cases, consists of two parts. It must always be what we call a binary liquid. We find a decomposition taking place, and in the cell before us the sulphuric element goes

Fig. 2.



to the zinc and combines with it, and the copper element is deposited on the copper. Now this is also the case in every kind of cell that I have already brought before you, and in every one that I intend to bring before you in the future. Here is a diagram representing the large cell which was placed in front of the table in the first lecture, and you will see that we have zinc which is coloured blue, and copper which is coloured red. These were immersed in weak sulphuric acid, and the two were joined, either by touching the metals together, or by means of a wire which is here represented. When this junction took place, a decomposition in the liquid ensued. This decomposition showed itself in various ways, but, among others, by the bubbles of hydrogen gas not appearing upon the zinc, but appearing upon the copper as they are represented here. These bubbles are supposed to be rising up in the liquid.

Fig. 3.



Now I want to introduce new terms to you. I have spoken of this liquid being split asunder, or divided into two parts in every case. I shall have

to use the words "positive" and "negative," perhaps, a good deal presently. We speak of these two metals as being positive and negative. We do not mean that they are of opposite characters exactly, only the one is what we call positive to the other; the one has a greater power than the other. One is stronger than the other, as I said in my previous lecture; and so we speak of silver as negative, and mercury as positive, because it is stronger than silver. The potassium is the strongest of them all, and therefore, of the metals of our list the potassium is the most positive, and the silver is most negative. You recollect how potassium will turn out magnesium, and magnesium turn out zinc, and zinc will turn out tin, and tin will turn out copper, and copper will turn out mercury, and mercury will turn out silver. That is the chemical meaning of the terms "positive" and "negative."

But suppose we look at it in another way, and we take these two different metals, and cause them to touch one another. We should find that by the mere contact of the two metals they get into opposite conditions one to the other. If I had pleased to make the experiment, I could have shown you that there was electricity produced by the touching of them together, and that they were in different electrical conditions. They have what electricians call different "potentials," and the one is positive to the other. I mean without any sort of liquid being between them at all. I have not, however, made any arrangement for showing it. That fact belongs rather to the physical side of the subject, and belongs to the course of lectures which Professor Tyndall has announced to deliver here in the course of the spring, and my department is rather the chemical side of this subject.

Again, every liquid that is split up is split up into two parts, which stand in the same relation of positive and negative to one another. So that when we have a splitting up of the sulphuric acid, the hydrogen is called the positive element, and the sulphuric element is called the negative element. In the cell the zinc is positive, and the hydrogen in the sulphuric acid being positive, it goes and joins itself to the negative, that is the copper plate. There is supposed to be a passage or current, and it is assumed that the movement is from the positive to the negative, and hence these little arrows that show the movement that takes place are represented as going from the positive towards the negative; and thus the positive metal or hydrogen is deposited against the negative plate. I said that if we make the two metals touch one another, we get them in these two conditions—positive and negative. If we examine them and see which is the positive and which the negative, we find just the same order as in the chemical series. Potassium is positive to magnesium; magnesium is positive to zinc; and so on. When liquids are employed the order depends a little upon the liquids; but still, if we employ the dry metals, we shall range them in the same order as in the list which was written on the blackboard at the last lecture.

Well, then, there is some force, no doubt, exhibiting itself in two ways, either as the chemical force or as the voltaic force. Now, if we have these two metals touching, we have a certain electrical effect produced. This electrical effect is capable of starting a chemical effect. I showed you in the last lecture that, when we had a chemical effect produced by replacement of metals, it started afterwards a voltaic effect. Did I not? Now, conversely, the two united metals being at a distance from one another, they will often start a chemical effect in the liquid between them. For instance, if we take perfectly pure zinc, or amalgamated zinc, and immerse it in sulphuric acid, there is no action between the two; but directly we join the zinc with the copper plate, we have an action produced between the two; so that we have, in this instance, a voltaic force producing a chemical force, and in the case of the branching crystals, chemical force producing a voltaic force.

But now I want to show you more fully that, when two metals do touch, they cause a splitting asunder of compound bodies. If I were to take a piece of zinc and a piece of copper, and keep them far apart in pure water, there would be no visible action; but suppose we make the zinc and the copper touch at a great number of places, we multiply the number of effects amazingly, and we decompose the water. This has been carried on in a great number of instances by Mr. Tribe and myself, and Mr. Tribe has kindly undertaken to superintend the experiments which I shall now show you.

This flask contains something which, at a distance I dare say, looks a very uninteresting black substance. It is zinc foil. There are two yards of this zinc foil crumpled up, and it has just had a little sulphate of copper poured over it. You understand what has happened. The copper is deposited of a black colour upon the zinc foil. This copper being deposited in fine crystals upon the zinc, touches the zinc in a million different places, and this causes a visible action upon the water. I had some pure water poured upon it, and it has been standing there since a quarter before three—now exactly half an hour. Here are the bubbles which are rising up. That amount of gas has been collected during that half hour. I will not say what it is just now. As the action goes on, I dare say we shall collect a great deal more. That is taking place at the ordinary temperature of the air. We will now take some at a higher temperature. We will take hot water instead of cold, and then see whether it does not act very much more rapidly. I may say that this decomposition of water is only a type of a great number of decompositions which we can produce. We can destroy a great number of other substances besides water in this way: for instance, chloroform, iodide of ether, and similar organic liquids. Mr. Tribe and I have worked them out, and found that two metals, in conjunction like this, are capable of splitting asunder these bodies and producing new compounds—some of these compounds being perfectly new to chemists, and not known before at all. Here is hot water poured upon the foil, and we will collect the gases in this little glass vessel. There goes the gas bubbling up much more rapidly than before Well, that experiment will take, I suppose, two or three minutes to collect any quantity. In the meantime, suppose I give you a little digression—a little episode.

I do not know whether you noticed at the end of the notes of the last lecture that there were some Latin words, and that I had spoken of the *Arbor Saturni* and the *Arbor Dianæ*—the tree of Saturn and the tree of Diana. I meant by the tree of

Saturn—the lead tree which, you remember, was standing on the table, and where the lead was growing about the zinc. The tree of Diana is the little silver tree, where the silver was built up upon the mercury. I do not know whether it will occur to any of you to enquire why they were called Saturn's tree and Diana's tree. It is a curious story, and if I were to tell you all about it, it would lead me a long way from the subject of the lectures. However, while the experiment is going on, I will just say a word about it. It belongs to the old philosophy of the East. The alchemists—the first chemists—used to consider that there was a good deal of connection between these different metals and the planets. The planets, you know, were named after many of the gods of antiquity; in fact they were worshipped, and were supposed to influence the doings of men in various ways. Astrology is mixed up with this subject; and the ancients considered that lead was connected with Saturn, and that silver was connected with the moon or Diana; tin with Jupiter; gold with the Sun, and Mercury with what was then called quicksilver. It is a metal like silver in appearance, only it moves about as though alive. Venus was supposed to be connected with copper, and iron with Mars. I think I have run through the seven. These names still stick occasionally to the metals, and when we speak of the lead tree we call it still the tree of Saturn. Saturn was considered to be very dull and dark. In fact, Saturn, in the old Indian mythology, meant the sun when under the earth, or the sun at mid-winter, such as the period we have just passed; and Jupiter, in that mythology, was the clear bright sky or the sun in his triumph. And so Saturn was originally not a planet, but the sun when obscured—the sun when dark and dull as at mid-winter. The astrologers imagined that that which was Saturnine—that which belonged to Saturn—was always dull, and heavy, and lead like, and that which belonged to Jupiter was bright. It was the bright metal tin that they called by the name of Jupiter. The idea remains in our language in the two terms "saturnine" and "jovial," because we speak of a man as being saturnine when he is dull and leaden, and we speak of his being jovial when he is bright and sunny.

While I have been giving you this little astrological episode the gas has been collecting to some extent—hydrogen gas. We will let it go on a little longer before trying its properties. In the meantime I will proceed with the more scientific part of my discourse.

The decomposition which takes place in the silver tree, in this electrotype apparatus, and in all these various cells which I have brought before you of one kind and another—for there is decomposition taking place in all these cases—is what we call electrolysis. Any of you that are Greek scholars will know that this term comes from words signifying loosening or tearing asunder by means of electricity. I have called it "primary electrolysis" when it takes place in the cell, and no galvanic action can take place at all without this primary electrolysis—the splitting up of something or other. Well, supposing we have that action once started, we find that if we were to take any part of the couple, and try what is going on anywhere, whether in the zinc plate or in the copper, or in the wire, we should find that it would be quite possible to make a similar chemical decomposition anywhere throughout the course of the metals. Now that is what we call "secondary electrolysis." It is produced by the first electrolysis, but it is carried on outside the cell.

I will now show you the decomposition of water, and of some other things in that way. You know that water is a compound of two substances—oxygen and hydrogen. This was discovered before voltaic batteries were known, and it was finally proved by Cavendish in an apparatus like this. He put into it hydrogen gas and oxygen gas, and found that by causing a spark to go through the gases, they combined together and produced nothing but water. He discovered also that there must be two measures of hydrogen to one of oxygen, in order to produce water without any residual gas. I will just show you a little of this gas called oxygen. The hydrogen you have already seen. You know that hydrogen burns if you put a light to it, but it will quench the light if you put the light into it. Now this oxygen will not burn, but it will support the combustion of other things. Here is some oxygen gas, and I will just make this piece of charcoal red hot, and put it into the oxygen. [A small piece of incandescent charcoal was accordingly introduced into a jar of oxygen, the result being the rapid burning of the charcoal with brilliant coruscations.] There it goes. If I had taken other things they would also have burnt with (I was going to say) equal brilliancy and beauty, but that would be saying too much; for I have chosen charcoal because it gives you these beautiful scintillations. If any of you want to try it, choose a piece of charcoal made from the bark rather than the wood of the tree, for that scintillates the best.

I will now take water, and decompose it by means of a battery. The cells are out of sight, but here are the wires. This water has been coloured in order that you may see it the better. It is pure water with the exception of a little colouring matter. I take these two wires of the battery and join them. They will communicate with these platinum plates which are in the vessel of water. There is no mystery about these platinum plates or "poles," as was once thought; they are just the means by which the power goes into the water. At one of these platinum plates hydrogen gas is being given off, and at the other platinum plate oxygen is being given off. We shall allow that process to go on for some little time. I use platinum, not because there is any particular virtue in that metal; but if I had employed zinc plates the oxygen would have gone to the zinc and made oxide of zinc, and we should never have been able to obtain the oxygen gas in a separate form.

While that is going on, however, I will show you another indication that hydrogen does produce water when combined with oxygen. We will burn this gas as, you remember, we did in the first lecture. Then, if we hold over the flame any cold glass vessel like this, you will see at once that the vessel becomes damped with the water which is being formed by the burning hydrogen, and which condenses on the cold glass. [A jet of hydrogen was then ignited under an inverted glass vessel, upon the sides of which moisture was deposited.] This water has been formed by means of the hydrogen of the flame combining with the oxygen of the air.

Now there is a rapid action going on in the apparatus in which the water is being decomposed by the battery. The bubbles of gas are rising quickly. You see that these two kinds of air are being produced out of the water which is being decomposed, and you remember the properties of these two gases. The hydrogen burns as you see it here, and oxygen, as you saw just now, does not burn itself, but is capable of setting various substances into very violent combustion when they are ignited and brought into it.

Let me call your attention to a remarkable thing that is happening. We had some colouring matter put into the water that is being decomposed, and you will see that in one of the tubes it is entirely bleached. That is not because of the oxygen, but because some ozone has been formed during the process. That ozone has had the effect of destroying the colouring matter. [The hydrogen resulting from the decomposition of the water, and collected in a separate tube, was liberated by means of a stopcock, a lighted taper being applied as the gas issued from the jet.] We have there the

Fig. 4.

hydrogen burning. In the other tube we have the oxygen, and we will see whether the gas will relight this piece of wood if I blow out the flame so as to leave the end of the stick red. [The oxygen was allowed to issue from the jet and impinge upon the incandescent stick. The stick immediately burst into a brilliant flame.] I will now partly blow it out again. You see the oxygen ignites it again. [This experiment was repeated three or four times consecutively.]

Now, supposing that instead of our decomposing water in this way, we decompose it in a vessel in which the gases can be collected together. Here are two platinum plates which rise up into this glass vessel filled with water; the wires of the battery will be attached, and we shall find that the gases will form rapidly when the current is passing. There go the gases; and now we have these gases mixed together, and we will collect them in soapy water, and make bubbles with them. We know that in these bubbles we shall have mixed together the hydrogen which burns, and the oxygen which helps it to burn. [A light was applied to the bubbles of mixed gases, and they exploded with a loud report.]

Well then, I think, we want no further convincing that this galvanic or voltaic power is capable of splitting asunder water into these two gases. Now this fact was taken advantage of by Professor Faraday as the measure for the amount of this power, and he contrived this apparatus which I have been employing. It is called a voltameter (Fig. 4). It is used for the decomposition of water, and we can measure the amount of the mixed gases which are given off, in a certain period, by any current that we wish to estimate. This apparatus which I hold in my hand was, I believe, the first voltameter that Faraday made. It is one roughly constructed by himself, and you see it is made of two little vessels which are used to hold the water; there is a cork fitted into the wider vessel, and it is bored so as to admit of the passage of the narrower tube. And then he has, I suppose with his own hand, caused two wires to pass through this tube, by melting the glass and poking the wires through. He then joined the wires with the battery, and having filled the whole thing with water, he was able to decompose the water, and collect the gases in the upper part of the tube, which has been roughly graduated into so many measures. They look like inches divided into tenths. This is Faraday's own original voltameter; but it has since been, of course, modified in a vast variety of ways.

(To be continued).

THE ROYAL INSTITUTION.

Notes of a Course of Seven Lectures on Electricity. By Professor Tyndall, LL.D. F.R.S.

February—March, 1875.

Experiments in Lecture I.

(1.) Place an egg in an egg-cup, balance a lath upon the egg; amber rubbed with the hand attracts the lath. The amber ought to be warm, and the hand dry: if the hand fails, a rub on the coat sleeve will render amber attractive.

(2.) Warm rock-crystal, or warm glass, rubbed with dry hand, also attracts lath. Gutta-percha and ebonite drawn through the hand do the same. A single stroke of a silk handkerchief considerably augments attractive force. This illustrates the influence of the rubber noticed by Newton.

(3.) Ebonite comb passed through the hair powerfully attracts the lath; comb supported by egg is in its turn attracted by lath. This is Boyle's experiment.

(4.) Ball of sulphur mounted so as to be caused to rotate rapidly, with dry hand placed against it, emits light in the dark. This is Otto von Guericke's experiment. A tall glass jar rubbed with silk smeared with amalgam yields vivid streams of "electric fire," which are seen much farther than the light from the sulphur. In all cases where he

development of sparks and crackling is the object, the glass tube and rubber ought to be not only warm, but *hot*.

(5.) Attraction of water and of oil by rubbed amber. An eminence forms under the excited amber, and the crest of the eminence is finally discharged against the attracting body. A strongly excited glass rod brought near the oil (contained in a very small watch-glass quite filled with the oil) raises several eminences, each of which discharges a shower of drops against the rod. This, in an intensified form, is the experiment of the Florentine Academicians.

(6.) Exhausted glass tubes, well warmed and dried, are filled, when rubbed with silk, with diffuse light. When the tubes contain uranium glass, or any other fluorescent body, the light is intensified.

(7.) Mercury in an exhausted tube, shaken to and fro, produces light, which is also intensified by the presence of uranium glass. These are the effects observed by Picard, Bernoulli, Hauksbee, and others.

(8.) Cork protruding from glass tube; penholder, or fir stick some feet in length, stuck into cork, attracts the balanced lath when the glass tube is excited.

(9.) The *approach* of the excited glass tube suffices to develop attractive power at a distance. Support long lath by warm glass tumbler; place fragments of paper, or gold leaf, under one end of lath, and bring excited tube near the other end; the two ends may be many feet apart; the light bodies are attracted.

(10.) A small plate of metal or of wood resting on a glass support—a warm tumbler would answer—is connected with one end of a wire 100 feet long, supported by loops of silk; the other end of the wire is coiled round the end of a warm and dry glass tube. Over the plate of metal or wood rests the short arm of an index, formed of a straw delicately poised. When the glass tube is excited by rubbing, the "virtue" is transmitted through the wire, and communicated to the plate; the end of the index is drawn down, its arrow-head moving upwards, through a foot or more, in consequence.

(11.) When the wire is supported by loops of [illegible] the effect is not obtained. When supported by loops of humid packthread the effect is not obtained; when, instead of the 100-foot wire we employ 100 feet of silk string, the electricity does not pass. But the silk string, when wetted, freely transmits the power. These are the experiments which led Stephen Gray to the discovery of conduction and insulation.

(12.) Support board by stout silk strings. A man stretched upon the board presents his forehead to one end of our straw index. On bringing excited tube near the man's feet his head attracts the short lever of the index, the arrow-head of which moves accordingly. If the index comes sufficiently near the forehead a spark passes between both. This experiment unites those of Stephen Gray and Du Fay.

(13.) Silver leaf let loose in the air plunges towards an excited glass tube, halts before it reaches it, and retreats. It may then be chased by the tube through the air. While thus repelled by the glass, it is strongly attracted by rubbed ebonite or gutta-percha.

(14.) A glass tube, indented at its centre, and supported on a point like a magnetic needle, is, prior to being rubbed, attracted by the excited glass tube; after being rubbed it is strongly repelled. In this condition it is strongly attracted by a rubbed resinous body. A rubbed ebonite comb, paper-cutter, or ruler, properly suspended or supported, is repelled by a second piece of ebonite similarly rubbed. It is attracted by rubbed glass. Speaking generally, the rubbed vitreous body repels the rubbed vitreous body; the rubbed resinous body repels the rubbed resinous body; while the one class when rubbed attracts the other class. This is the fundamental law of electric action established by Du Fay. It is usually expressed by saying that like electricities repel, and unlike electricities attract each other.

NOTES OF LECTURE II. *February* 11, 1875.

1. For a long period bodies were divided into *electrics* and *non-electrics*, the former of which were held to be capable of electrification, the latter not. It is now time to say that the distinction between electrics and non-electrics is really a distinction between insulators and conductors. The conductors being held in the hand, and rubbed, the excited electricity immediately escaped, while it was retained upon the surfaces of insulators. When properly insulated the most perfect conductor can be electrified by friction.

2. The sulphur sphere of Otto von Guericke was, as already stated, the first form of the electric machine. For this Hauksbee and Winckler substituted globes of glass; Boze of Wittenberg (1741) added the prime conductor, which was first a tin tube supported on resin, or by strings of silk. Gordon, of Erfurth, soon afterwards substituted a glass cylinder for the globe. The cylinder was sometimes vertical, sometimes horizontal. He so intensified his sparks as to kill small birds with them. In 1760 the plate-machine now in use was introduced by Planta.

3. Various attempts had been vainly made by Nollet and others to ignite inflammable substances by the electric spark. This was first effected by Ludolf, on the first opening of the Academy of Sciences at Berlin, in 1744. With a spark from the sword of one of the court cavaliers present on the occasion he ignited sulphuric ether.

4. Grummert, a Pole, made various experiments on the luminous discharge through a vacuum. This we have already illustrated; but it is interesting to note that Grummert proposed to illuminate by this light mines in which ordinary flames cannot be employed, a proposal which has been revived with reference to the vacuum tubes of our day. Krüger found that the spark possessed a bleaching power, doubtless through the ozone generated, which was then unknown.

5. Dutour and Waitz, in 1745, and Dr. Watson about the same time, made further experiments on the destruction of electricity by flame. A flame, connected with the earth, instantly discharges an electrified conductor; glowing embers and pointed bodies do so also, but in a less degree.

6. Dr. Watson also made numerous experiments on the ignition of bodies by the electric spark. He fired gunpowder, discharged guns, and, causing a spoon containing ether to be held by an electrified person, he ignited it by presenting to it the finger of an unelectrified person. He noticed that the

spark varied in colour as the substances between which it passed varied.

Experiments in Lecture II.

As in Lecture I. we shall employ, in part, a lath balanced on an egg as our test of attraction.

(1.) A ball of brass, of wood coated with tinfoil, a lead bullet, or an apple, held in the hand and struck briskly with silk, flannel, or a fox's brush, fails to attract the balanced lath. Suspended by a string of silk and similarly struck, the attraction is decided.

(2.) A brass tube held in the hand and struck with the fox's brush shows no attractive power; but when a stick of sealing-wax, ebonite, or gutta-percha is introduced into the tube as a handle, the striking of the tube at once developes attractive power.

(3.) The mere touching of the brass tube by the finger causes the power to disappear.

(4.) Removing the handle and exciting *it* by the friction of flannel, silk, or fur, it attracts lath. But it may be repeatedly touched, and still retain its power of attraction. In the case of the conductor the touching of any point causes it to yield up the whole of its electricity; in the case of the insulator only the spot touched yields up its electricity.

(5.) The human body was ranked among the non-electrics. I stand on the floor and permit an assistant to strike me briskly with the fox's brush. I present my knuckle to the balanced lath, but there is no attraction. Placing a board on four warm glass tumblers I stand on it: a few strokes of the fur suffice to develop a strong attractive power. Presenting my knuckle to that of my assistant, who stands on the ground, a spark passes between us. If I stand upon a cake of resin, of ebonite, or upon a sheet of good india-rubber, the effect is the same.

This action is considerably augmented by throwing a mackintosh over the shoulders and having it struck.

(6.) Thus non-electrics, like electrics, can be excited; the condition of doing so being that an insulator shall be interposed between the non-electric and the earth.

(7.) A sheet of foolscap, well warmed, so as to expel the humidity which paper always imbibes from the air, placed on a hot board, becomes strongly excited when india-rubber is passed over it. It resists removal from the board, and when torn away attracts the balanced lath from a considerable distance. If brought near a wall it will move up to it and cling to it.

(8.) Two strips cut from the excited foolscap, as it lies upon the hot board, are placed one upon the other. When laid hold of at one end and separated from the board, they violently repel each other. This is a consequence of the fundamental law already illustrated.

(9.) The gold leaf electroscope acts in the same way. When electricity is communicated to the metal top of the instrument it diffuses itself immediately over the gold leaves, which then repel each other like the strips of paper. The lightness of the gold leaf enables it to respond to very feeble charges of electricity.

(10.) A simple and effective electroscope for teaching purposes (devised by Mr. Cottrell) may be formed of a straw about 18 inches or 2 feet long. Within two or three inches of the blunt end of the straw, a second or thinner straw about an inch long is passed transversely through the first. Half a stick of sealing-wax is stuck against an upright support, and a sewing-needle is fixed in the sealing-wax. This needle is introduced into the transverse inch of straw and serves as a horizontal pivot. The blunt end of the straw carries a little weight, just sufficient to keep the straw vertical. Thus arranged the straw is very mobile. It is attracted by any electrified body; but on touching the body it is charged and immediately repelled, the sealing-wax preventing the escape of the electricity. The straw index moves over a graduated arc.

(11.) The electrical machine, beginning with its first form as a sphere of sulphur, then as a globe of glass, then as a cylinder vertical and horizontal, then as a plate of glass, and finally as a plate of ebonite, was illustrated by examples.

(12.) Standing on an insulating stool and placing one hand on its prime conductor, the ebonite machine was worked: the knuckle being brought down upon a spoon containing sulphuric ether, a spark passed and the ether was ignited. The spoon was next held in the hand of the excited person, and ignited by a spark from the knuckle of another standing on the earth. These are the experiments of Ludolf and Bishop Watson.

(13.) The presentation of the point of a penknife to the prime conductor at a distance of three inches prevented almost wholly the charging of the conductor.

(14.) Mounting a pointed rod upon the prime conductor, a strong cool wind issued from the point when the machine was worked. This wind was competent to blow aside a sheet of paper. When the point was turned downwards the "electric wind" forcibly depressed the flame of a candle placed underneath the point. Franklin, as we shall afterwards learn, turned these experiments to important account.

(15.) A cross was formed of four wires, the pointed ends of which were all bent in the same direction so as to form a right angle. A brass axis passing through the intersection of the arms of the cross was permitted to rest upon two parallel wires supported by glass rods. One of the parallel rods being connected with the conductor of a machine, the whole system was electrified. From every point issued the "electric wind," the reaction of which caused the cross to rotate and roll from one end to the other of the parallel bars. This is a form of the "electric mill," devised by Hamilton.

(16.) The electric wind from a glowing body was shown by the sweeping away several times in succession of the black smoke from a wax taper after the flame was extinguished. The wick of the taper was here connected by a wire with the electrical machine. This and the last experiment were made after the manner of Canton, who employed in his observations the shadows of electrified threads, instead of the threads themselves.

(17.) The quickening of the flow of water by electricity was shown by suspending a metal bucket from an insulated arm, and connecting it with the electric machine. Through a small orifice in the bottom of the bucket water dropped slowly; when the machine was worked the drops quickened to a continuous stream.

NOTE REGARDING ACTION OF CURRENTS ON MAGNETS.

By Prof. W. E. AYRTON, Japan.

In the majority of treatises on Natural Philosophy rules are given to connect the way in which a magnet will be deflected with the direction of the current acting on it. These rules either have reference to an imaginary man swimming along the wire with the current, or to imaginary corkscrews. Both sets of rules are—as far as my experience with students has shown—most successful in producing confusion. In addition, in countries like Japan, where corks have been but recently introduced, and, therefore, where corkscrews are comparatively unknown, it is obvious that any rules depending on a familiarity with these implements must be far from being lucid.

The following, which I have found students easily remember and correctly apply in any case, are therefore, I think, worthy of publication in your Journal:—

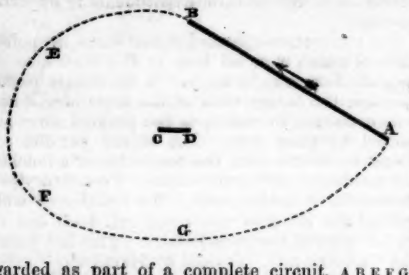
Let rotation opposite to that of the hands of a watch be called (as it always is in trigonometry and mathematics generally) *positive rotation*, and the reverse *negative*.

Let the "north-seeking end" of a magnet (English "North Pole;" French, "Le Pôle Austral") be called, as Faraday termed it to avoid confusion, the *marked end*, and the opposite end the *unmarked end*.

Let the observer look at a coil of wire along the axis of the coil, that is, along a line perpendicular to the plane of the coil, then—

I. If the direction of rotation of a current in a coil of wire encircling a magnet be positive, the marked end of the magnet will come towards the observer; or if negative, the unmarked end.

II. If a current pass along any wire (A B) placed anywhere near a magnet (C D), then it may be



regarded as part of a complete circuit, A B E F G, encircling the magnet; consequently, if the current flow from A to B, the direction of rotation of the current is positive,—therefore the marked end of the magnet will come towards the observer, and *vice versa*.

Electro-Magnets.

III. If the direction of rotation of a current round a piece of iron be positive, the end of the iron nearest the observer will become a marked end, and consequently the other end of the piece of iron an unmarked end.

These rules, and especially the latter one, have the advantage of not referring (as the ordinary rules do) to which end of the coil the current enters; all the observer has to consider is simply—

Is the direction of rotation of the current positive or negative?

If *memoria technica* be desired, we have—

*N*egative rotation of current.	u*N*marked end comes to observer always.

Notes.

It is not often that a telegraph ship has to pass the ordeal of a military bombardment. This has happened to the *Caroline*, while laying a short cable on the coast of Spain. The Carlists have driven her off her work, and she is now engaged in repairing the Lizard cable.

The well-worked and well-managed Indo-European line, which has on its Board names so well known in telegraphic circles as W. H. Barlow, C. W. Siemens, and H. Weaver, has obtained—in the year 1874—an increase of 45 per cent on its receipts, they having risen from £54,897 in 1873 to £79,466. The Government have agreed to reduce the rent payable by the Company for the use of the land and cable wire from £12,000 to £6700 per annum.

The Telegraph Construction Company have netted upon their last year's contracts a profit of no less than £371,381. They had constructed, to the end of the year 1873, 37,211 miles of cable, and they have added to this vast mileage about 5973 miles, laid in 1874.

The Anglo-American Company have resolved to reduce their tariff to America one-half on May 1st.

The tallest and largest telegraph pole in New York, perhaps in the world, was raised in Fulton Street, near St. Paul's Church, on January 17th. It is to be used to support the distributing wires that will extend from the new building of the Western Union Telegraph Company at Dey Street and Broadway. The pole is 93 feet long and 2 feet in diameter, and reaches high above the neighneighbouring buildings. The raising required the labour of a large number of men and two horses, and completely blocked the street for some time. The tree from which the pole was made was of Californian growth.

The *Sydney Hall* has just left Messrs. Siemens's works, North Woolwich, with a cable for the Montevidean and Brazilian Telegraph Company, and she will be shortly followed by the *Ambassador* with the cable manufactured to replace that lost in the *La Plata*.

The *Hooper* has successfully laid the cable between Trinidad and St. Croix, the insulation of which is reported to be superb.

Mr. Stearns is in Paris, busily applying his duplex system to the Hughes printing apparatus, which is the favourite instrument in France—Morse being nowhere. He has been very successful between Paris and Versailles, Rouen and Havre. Mr. Stearns is sure to be successful anywhere, for he certainly is one of the ablest practical electricians of the day. It is very gratifying to see how his success, and that of his countrymen generally, fail to produce the smallest symptom of national jealousy in England. Truly in Telegraphy Anglo-Americans form but one nation.

The following statistics of a "healthy" office, taken from the *Journal of the Telegraph*, are interesting:—

Kansas City, Mo., ten years ago, had a population of about 4000. It has now 40,000. The following is the telegraphic work done therein during the month of December:—

Number of messages handled	30,441
Reports and specials, 106,997 words, reduced to message basis	5,349
Total number of messages	35,790
Number of operators, including chief	7
Daily average messages to each operator	204

Mr. Haskins has suggested and experimented upon the use of condensers as relays, and an interesting paper was read by him to the American Electrical Society on this subject.

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

INAUGURAL ADDRESS, BY MR. LATIMER CLARK, PRESIDENT. JANUARY 13, 1875.

(Continued from page 47.)

REVERTING to the progress of the telegraph in England, we find Mr. Cooke in 1837 in negotiation with the directors of the London and Birmingham Railway for laying down a telegraph from London to Birmingham, a project which did not, however, arrive at completion. In the following year (1838) Mr. Cooke conducted some extensive experiments at St. Katharine's Docks, in which he exhibited the telegraph in operation through 110 miles of No. 16 covered copper wire. Mr. Brunel at this period took up the matter, and a line of pipes with five wires was laid down on the Great Western Railway from Paddington to Drayton, which was afterwards extended to Slough in 1841. The total cost of this line to Drayton was £3270 6s. The insulation becoming defective, the pipes were removed and sold, and poles and iron wires were erected in their place in 1841, the wire being in the first instance temporarily insulated on quills. In 1840 Mr. George Stephenson adopted it on the Blackwall Railway, which was then worked by a stationary engine and rope. In 1841 Sir Charles Fox ordered a telegraph on the Cowlairs and Glasgow Line. It was then fixed on one of the Midland tunnels, and on the Dublin and Dalkey Atmospheric Railway.

In 1842 Mr. Cooke was in negotiation with the Admiralty in reference to a line from London to Portsmouth; he also published a book termed "Telegraphic Railways on the Single Way." In this year plans for the Norwich and Yarmouth Line were approved by Mr. George Hudson. In 1843 the telegraph was ordered for the Dalkey and Kingstown Atmospheric Railway by Mr. Samuda, and on this line galvanised iron wire was first employed. The Norwich and Yarmouth Railway, a single line, was opened in May 1844; the Northampton and Peterborough Line and the Croydon Line were completed in 1845. These were followed by the South Western Line from London to Gosport, and the South Eastern Line, the first portion executed being the Maidstone Branch.

It appears that the funds necessary for the management of the partnership were provided by Mr. Cooke, and the results were at first by no means encouraging. His account books, which were produced in evidence during an arbitration which took place in 1841, before Marc Isambard Brunel and Professor Daniell, showed that, prior to his connection with Professor Wheatstone in February 1837, he had expended £385 8s. 10d. on his experiments; by the end of 1843 this deficit had increased to £6232 16s. 1d.

The celebrated message which led to the capture of John Tawell, a quaker, who had committed a murder at Slough, was sent on the 1st January, 1845, and it had a powerful influence in arousing public attention to the value and capabilities of the telegraph.

In erecting the Blackwall Railway Mr. Cooke made the acquaintance of Mr. George Stephenson and Mr. George Bidder, and in 1842 Messrs. Cook and Wheatstone inserted a series of advertisements in the *Railway Times* and other papers drawing attention to the merits of their invention. These circumstances eventually led to Mr. Cooke's introduction by Mr. Bidder to Mr. John Lewis Ricardo, M.P., afterwards for many years Chairman of the Electric Telegraph Company, a gentleman by whose energy and enterprise the Company was created and led to a high pitch of prosperity. The first interview took place on the 1st of October, 1845, and so prompt and decisive was their action that on the 17th of that month Mr. Ricardo and Mr. Bidder wrote a joint letter to Mr. Cooke accepting the terms he had proposed.

The Company was registered on the 2nd of September, 1845, and a provisional prospectus was issued shortly afterwards.

The first directors were Mr. J. L. Ricardo, Mr. Sampson Ricardo, Mr. W. F. Cooke, Mr. George Bidder, and Mr. Richard Till. An Act of Parliament was obtained on the 18th June, 1846, and they commenced business, in an imperfect manner, at their first offices at 345, Strand, where they educated their clerks, the system employed being the Cooke and Wheatstone double-needle instrument.

The capital of the Company was privately subscribed by the directors above named, and it would appear that under the arrangements made with the patentees they received about £160,000 for their patents in money or value. This purchase included Mr. Cooke's half-share of the London and Portsmouth Telegraph and the telegraph to Slough. Out of this amount Professor Wheatstone received £30,000 in cash and £3000 for royalties then due, and Mr. Cooke received the remainder. I believe, however, that Mr. Cooke's personal share amounted practically to about £96,000, of which the greater portion was in shares, many of which were subsequently disposed of at a loss.

During 1847 the Electric Telegraph Company erected their central station at the end of Founder's Court, Lothbury, the funds for this handsome building having been provided by Sir Samuel Morton Peto. It was formally opened on the 1st January, 1848, and at this period 1514 miles of telegraph were either erected or in progress.

The business was not an uninterrupted success. On the first day they took about £20, but this amount steadily increased each day.

The large hall was filled up with instruments from top to bottom, each gallery being appropriated to a different division of the country, and having a staff of clerks ready to receive and transmit messages. I believe at that time the cost of a twenty-word message from London to Glasgow or Edinburgh was about 17s. 6d.; to Yarmouth 9s. 6d.; to Ipswich 5s. 6d.; and to Southampton 3s.

It was soon found that they had over-rated the immediate capabilities of the telegraph traffic; they had spent all their capital, and their expenditure greatly exceeded their receipts. It became necessary to effect a great reduction in their expenses, and on the 27th March at one swoop they discharged about four-fifths of their clerks, who were, however, re-engaged as their prospects improved.

The year which followed was one of great commercial disaster consequent on the French Revolution and the abdication of Louis Philippe. By the month of June, 1848, the operations of the Company had resulted in the loss of £3220 8s., and the whole undertaking might have collapsed had not Mr. Ricardo advanced money, and taken upon himself the burden of other shareholders, whose confidence in the Company had ceased. They were at this time receiving about £100 per week for messages, and by December their actual loss had been reduced to 341 0s. 11d.

In January, 1849, they were able for the first time to speak direct without delay from London to Birmingham and Manchester. This was considered a great telegraphic feat.

In the year 1850 their gross revenue from all sources was £43,524 3s. 9d., out of which they made a profit of £10,075 12s. 3d.

In 1851, the year of the Great Exhibition, their gross revenue was £49,866. In 1852, their receipts for messages amounted to £100 per day. In 1860, their revenue had increased to £214,245 7s. 3d., and their profits to £69,711 14s.

The 30th June, 1868, was the day fixed for the transfer of the whole system to the Post Office Department of Her Majesty's Government, but owing to various delays the actual transfer did not take place till the 28th January, 1870.

Their receipts for the thirteen months ending on this date were £425,789 2s., and their profits £202,480 6s. 2d.

On finally winding-up, the Company, in addition to interim dividends (which were limited by their Act to 10 per cent per annum), the shareholders divided among themselves a sum of £2,938,826 9s. received from the Government, and a Trust Fund of £40,721 17s., being equal to a dividend of £292 1s. 3d. per cent upon their capital.

The Electric Telegraph Company was not, however, allowed to pursue its way without opposition. In July, 1850, the British Electric Telegraph Company obtained their Act, their engineer being Mr. Edward Highton, and in the same year the Magnetic Telegraph Company was originated, their engineer being Mr. Charles Bright, and at first they employed the electro-magnetic instrument of Mr. Henley.

These two Companies afterwards amalgamated and became a powerful rival of the Electric Telegraph Company. The United Kingdon Telegraph Company obtained their Act in 1861, their engineer being Mr. Andrews, and they also erected an extensive system of telegraphs, and introduced the Hughes Printing Telegraph.

The Electric Telegraph Company endeavoured to establish a practical monopoly by either opposing or purchasing the inventions of rival patentees. Among these the chemical printing telegraph of Mr. Alexander Bain deserves especial notice. Chemical telegraphs were suggested at an early date, and in 1838 Mr. Edward Davy patented a chemically-marking telegraph of considerable merit, employing calico tapes moistened with iodide of potassium. In December, 1846, Mr. Bain patented his system, and in addition to the use of an iron style resting on paper moistened with a solution of ferrocyanide of potassium, described the important principle of setting up the messages on perforated paper, a system which has done more to increase the capabilities of the telegraph than any other invention.

That invention was exhibited to the Electric Telegraph Company, and while being examined one of the regulating springs broke and allowed the instrument to travel round with uncontrolled speed. To their surprise they found that the whole message was visible, and had been transmitted correctly at the rate of several hundred words per minute, upon which they resolved to purchase the invention without delay. I believe Mr. Bain received £7000 for his patent and for the withdrawal of his opposition to their Bill. They employed the system of printing on chemical paper for some years, until it was eventually supplanted by the Morse inking system. Nothing, however, was done with the punched paper until Sir Charles Wheatstone introduced his very beautiful automatic printing telegraph, which is the most rapid system of telegraphing at present in ordinary use.

The real capabilities of the Bain system remain, however, to be yet developed. The Americans have recently re-introduced it with startling results, and have shown that on ordinary circuits four hundred or five hundred words per minute may be readily transmitted by its means.

When the capabilities of this system become generally known to the public, they will doubtless insist on enjoying the advantages to be derived from it, either in the form of lengthened messages or a lowered tariff. It appears to me, that in order to obtain the full benefits of telegraphic communication any reduction in the cost should be accompanied by the introduction of *express messages*, a species of message bearing the same relation to ordinary messages that passenger trains bear to goods trains. The cost of these messages should be at least five or ten times as great as that of ordinary messages, and they should be subject to the same rules of priority among themselves as now exist, but they should in all cases take precedence of the ordinary heavy traffic. Without some such system much of the celerity to which we are now accustomed will be lost amidst the enormous accumulation of work which must sooner or later fall upon the telegraphic system of this country. The Electric Telegraph is quite capable of transmitting a large portion of the business of the country which is now transacted by letter, and is being so employed more and more every day. If this expansion of traffic be accompanied by facilities for securing rapid transmission for important messages the pecuniary gain to the "Post-office" will be very great, while the benefits afforded to the commerce of the country will be enormous.

(To be continued.)

POST-OFFICE TELEGRAPHS.—Statement showing the total number of messages forwarded from Postal Telegraph Stations in the United Kingdom during the week ended the 13th February, 1875, and during the corresponding week of 1874:—1875, 342,197; 1874, 352,426; decrease in the week of 1875 on that of 1874, 10,229. The large number of telegrams in the corresponding week of last year was due to the general election.—Week ended 20th February, 1875, and corresponding week of 1874:—1875, 347,108; 1874, 326,496; increase in the week of 1875 on that of 1874, 20,612.

Notices of Books.

Introduction to Experimintal Physics, Theoretical and Practical, &c. By ADOLF F. WEINHOLD. London: Longmans, Green, and Co.

THIS is a most excellent work, and worthy of the great house of Longmans. The author is Professor in the Royal Technical School at Chemnitz, the principal manufacturing town—the Manchester—of Saxony. It is admirably translated and edited by Mr. Benjamin Loewy, and it is introduced by a valuable preface on self-culture and self-tuition in Physics, by Prof. G. C. Foster, F.R.S., of University College, and one of the Vice-Presidents of the Society of Telegraph Engineers. We have so recently urged upon all students of Electricity the necessity of experiment, that it is a matter of great satisfaction to find a work so speedily produced to meet the views propounded. There is no doubt that the only way to impress physical facts upon the mind of students is to make them experiment themselves, and to let them draw their own deductions from their own observations. As Prof. Foster says—"In any sound system of teaching, particulars must come before generalities; for unless a student has clear conceptions of individual phenomena, it is impossible for him to understand their mutual relations, or the general conclusions that are based upon them." Mere reading or listening, or seeing descriptions and experiments, are not enough; the student must experiment and observe for himself not necessarily all the facts of a science, but certainly those illustrating the main elementary principles upon which the science is based. Interest is thus excited, thought is stimulated, reflection exercised. Here is a book which gives the fullest and clearest descriptions of the mode of making the simplest apparatus at the least cost, and the precautions necessary to enable the student himself to make the fundamental experiments in all the Physical Sciences, and in the elementary principles of Statics and Dynamics, on which Natural Philosophy is founded. The expensive ready-made apparatus of the instrument maker is as much as possible discarded. With very few exceptions, any one with a taste for mechanical occupations and a fair amount of handiness could—with patience, and by carefully following the directions given—make all the apparatus referred to in the book. Prof. Weinhold says himself:—

"The most indispensable qualification for one who wants to make real use of this book is *perseverance*. Skilfulness in practical operations—such as the working of metals or of glass, or in actually making experiments—is only to be obtained through practice; and since it is impossible for even the most carefully written instructions to provide against every mistake that a student can possibly make, personal experience must every now and then be the real teacher. Whenever anything does not succeed the first time, the student should try it again; but he should not try thoughtlessly, on the mere chance of better luck next time; he should endeavour, by careful consideration, to find out the cause of his ill success. The completion of a piece of apparatus, or the success of an experiment, well repays the trouble spent upon it; the skill that has been gained in the process never turns out useless afterwards, and occasions arise in which even those whose chief occupations lie in quite other directions are able to recognise its value."

The book deals with the general properties of matter, Mechanics, and all the other "ics," including Acoustics and Optics, Electricity, Magnetism, and Heat. The decimal (metrical) measurement is used throughout. That portion relating to the various motions of matter, especially the vibratory, is admirable. Names are avoided and history discarded as much as possible, and thus the author steers clear of the Scylla and Charybdis of national jealousy and individual vexation. The illustrations are very good, and the excellent plan is adopted of giving the scale to which every diagram is drawn. The electrical portion is perhaps a little behind the age; but this is perhaps owing to the fact that the age is rather too much in advance of the philosopher, for certainly practice in this science has shot far ahead of theory. Nevertheless, no student in any physical department should be without this much-needed book, not so much because it teaches him all that is worth knowing in Experimental Physics, but that it shows him the proper way to acquire a knowledge of that which is known by self-tuition and self-help.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences. Vol. lxxx., No. 4. January 25, 1875.

On the Effect produced by the Application of Armatures to Perfect Magnets.—J. Jamin.—An intricate article, replete with mathematical investigations, best studied in the original. The conclusions arrived at are—(1.) If a single armature be placed to the north pole of a magnet it does not in any way modify the magnetic condition of the unarmatured south portion of the magnet. If now we consider the effect of applying an armature to the magnet's south extremity, we find that the magnetism is lost, but is acquired by the armature: *this new distribution is in no way modified if we pluck off and attach the armature on the north extremity;* hence, regard being had to these armatures, there is an absolute independence between the two halves of the magnet. (2.) The application of an armature to one of the ends of a magnet provokes in it a new distribution, *but neither diminishes nor augments its previous quantity.* This fact does not appear directly from experiment, since the armature seems to gain more than the magnet loses. The cause of this difference is the different magnetic conductibility of the steel magnet and of the iron proof plane with which the strength of the magnet is estimated. The process of obtaining this estimate consists in dividing the surface of the magnet into small squares, and the sum of the square root of the wrenching forces necessary to detach a "proof plane" from the centre of each of these squares measures the total magnetism.

A note by E. Ducretet relative to the *Electro-Chemical Resistance offered by Aluminium when used as a Positive Electrode in a Voltameter.* He says—"A water-voltameter (containing acidulated water, platinum, and aluminium plates) in communication with the poles of a battery disengages hydrogen at the negative electrode, aluminium. If the current is reversed the water is no longer decomposed, and the current becomes excessively feeble. This phenomenon is produced instantly, however rapidly the currents are changed." M. Ducretet constructs, upon this principle, a *liquid rheotome*, permitting the passage of currents in one determined direction only, and points out the applications of such an apparatus to telegraph lines, electric bells, the explosion of mines, &c.

Les Mondes. Vol. xxxvi., No. 2. January 14, 1875.

Contains a long biography, by M. Dumas, of the eminent electrician M. Auguste De la Rive, and no other articles in any way touching upon electrical and telegraphic sciences.

No. 4. January 28, 1875.

Electric Light.—It appears that at the present time experiments are being carried on in Paris, for the

Russian Government, respecting the projection of electric light to great distances. The light is placed in a kind of box made from a large iron tube, 1·20 metres in diameter and 0·90 metre long. The front opening contains a lens, 1·15 metres diameter, which completely closes it; the other end is closed by a copper lid supporting a reflector. In this lid two peep-holes—similar to those in the stereoscope—are arranged, by which to examine the luminous focus. The range of this apparatus is more than 15 kilos. (nearly 10 miles), and at that distance objects included in the luminous cone are tolerably lighted up. The distance of the carbon-points is regulated by clock-work.

No. 5. February 4, 1875.

Camacho's Concentric Tube Electro-Magnet.—Already described in our columns (vol. ii., p. 342), to which we refer our readers.

New Electric Light (discovered by M. Ladygene, and of which particulars were detailed in vol. ii., p. 202, of this Journal), has been deemed of such importance by the Russian Academy of Science that they have awarded him the Lomonossow Prize.

Annalen der Physik und Chemie, von J. C. Poggendorff. 1874. No. 10.

On Electric Currents produced by the Non-simultaneous Immersion of Two Copper Electrodes in Various Liquids.—G. Quincke.

Appendix:—*On the Presumed Relations between Capillary and Electric Phenomena.*

Preliminary Experiments with a Magnetised Copper Wire.—B. Stewart and A. Schuster. See TEL. JOURN., vol. ii., p. 193.

On the Question of the Duration of Propagation of Magnetic "Actio in Distans."—H. Herweg.

On a Modification of the Electro-Magnetic Rotation Experiment.—H. Herweg.

Comparison between Electric Machines. M. Mascart.

Measurement of the Electro-Motive Power of Voltaic Batteries in Absolute Units.—A. Crova. See TEL. JOURN., vol. ii., pp. 204, 277.

Induction Action of Magnetic Rods of Unequally-Hard Steel.—L. Külp.

No. 11.

Thermo-Electric Studies.—E. Budde.

Checking of the Torsion Vibrations of Wires.—H. Streintz.

On Galvanic Resistance to Conduction.—H. Herweg.

No. 12.

Experimental Investigation on the Behaviour of Non-Conducting Bodies under the Influence of Electric Forces.—L. Boltzmann.

On the Play of the Electrophorus Machine, and on Double Influence.—P. Riess.

Criticism in Electro-Dynamics.—H. Helmholtz.

Conduction of a Current by Metallic Sulphides.—F. Braun.

Remarks concerning the Theory of Electricity.—R. Edlund.

Remarks on an Electro-Dynamic Experiment.—F. Zöllner. F. Lippich.

Bunsen's Carbon-Zinc Battery made Self-Evacuative.—A. Gawalowski.

Revista de Telégrafos. No. 24, Anno xiv. December 15, 1874.

The "official section" contains a decree authorising the construction of a submarine telegraph connecting San Sebastian with Fuenterrabia.

The members of the telegraphic staff of Cuba and Puerto-Rico have addressed a memorial to the Minister for Transmarine Affairs, complaining that vacancies arising in those islands are supplied by telegraphists from Spain, and that thus their prospects for promotion are practically extinguished.

The non-official portion contains a paper on the method of testing the electric condition of submarine cables, extracted from the work of A. L. Ternant on Submarine Telegraphy, with notes by T. Picco.

The Minister of War is about to employ the nocturnal optical telegraph of D. Enrique Bonet in the campaign in the north.

The Government of the United States of Colombia, which undertook in 1864 the construction of its telegraphic system, possesses now 1600 kilos. of lines in service, uniting the capital with the principal cities of the north of the Republic, and with the port of Buenaventura on the Pacific. At that port the above-mentioned net-work of lines are to be connected with the submarine cables of the west coast of South America to Peru and Chili, which, ascending northwards as far as Panama, will meet there the system of communications established between America and Europe.

The steamer *Vandalia*, of Hamburg, caught with its anchor the cable from Jamaica to Colon, on the 4th of November last, causing a damage of small importance, which was quickly repaired, without the service of this important line having suffered any serious interruption.

The *Fanfulla*, speaking of the meeting held for erecting at Bologna a monument for the illustrious physicist L. Galvani, says that the designs given in were twenty-three in number, the jury deciding in favour of the young Roman sculptor Cencetti. The artist has selected the culminating point of the scientific life of Galvani, in which the immortal Bolognese is attentively watching the electric phenomena manifested in the movements of the frog. The expression of the face and of the whole body reveal the anxiety of the man of science and the emotion produced by a great discovery.

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Continuation of *Schwendler's General Theory of Duplex Telegraphy*, of which we have already given the author's principal conclusions.

New Lightning Protector for Telegraph Lines (Lemasson System).—Among the different lightning protectors invented to protect telegraph lines, one of those most used is formed of two plates furnished with points and insulated from each other, one plate being traversed by the line current, and the other placed in communication with the earth. So long as atmospheric electricity is moderate the current goes through the first plate only, but when excessive it runs to earth through the points and the second plate. M. Lemasson proposes to render such a lightning protector of greater efficiency. He places a tube inside a conducting mass, provided with 100 transverse striates, and in immediate contact with earth. A cylinder communicating with the line occupies the centre of the tube, but does not touch it, and is provided with 40 longitudinal striates. By reason of the different direction of the striates, 4000 crossings are obtained,—uniformly distant ½ a millimetre from each other,—and these crossings may be regarded as so many points. Hence, although measuring only 1 decimetre in length by 4 centimetres wide and broad, M. Lemasson's arrangement, though much smaller, is more efficient than that in ordinary use. An important addition to the apparatus is the insertion of a pipe (furnished with a stop-cock) to the air-space between the "tube" and the "conducting mass," so as to rarefy the air, and thereby diminish the resistance offered to the discharge of excessive atmospheric electricity.